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THE GEOCHEMICAL CHARACTERISTICS OF LOESSES AND PALEOSOLS IN THE SOUTH-EASTERN TRANSDANUBE (HUNGARY)

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ABSTRACT

This paper deals with a study on loesses and paleosols in the South-Eastern Transdanube. Four types of the sediments (loess, derasional loess, humic loess horizon, chernozem-like steppe soil) from the profiles of the Dunaújváros-Tápiósüly and the Mende-Basaharc loess formations were examined. Loesses can be divided into two groups (weakly weathered loess and weathered loess) on the basis of the element composition, which is also affected by paleoclimatic circumstances and weathering processes. Beside an average element composition, the weakly weathered loess is characterized by high carbonate content and low calcite-dolomito ratio. The characteristic element composition of the loesses is considerably changed during the weathering because some elements accumulate and others decrease. There is characteristically lower carbonate content in paleosols than in loesses, but they have higher calcite-dolomite ratio. The humic loess horizons have geochemically an intermediate character between loesses and paleosols. Mineral and element composition of the chernozem-like steppe soils prove that their pedogenesis was more intensive than that of the humic loess horizons.

Keywords: loess geochemistry, young loess, paleosols, carbonate content, major components, trace elements, correlations.

INTRODUCTION

On the basis of their lithologic properties, loesses of Hungary can be divided into two well-distincted groups: young loess and old loess (PÉCSI 1975, 1985, 1993). Upper part of the young loess is the "Dunaújváros-Tápiósüly subseries" (its age is cca. 12–16 ka B.P.), and the lower part of it is the "Mende-Basaharc subseries" (with an age of cca. 27–120 ka B.P.) (PÉCSI 1975, 1985, 1993).

Several exposures of the loess-paleosols series can be studied in the South-Eastern Transdanube. Loess and derasional loess of the area, which mostly contain humic loess horizons, chernozem-like steppe soil horizons and brown forest soils, can be assigned to the "young loess" series (Dunaújváros-Tápiósüly loess formation and Mende-Basaharc loess formation).

During the last decades sevaral papers have appeared on the geochemistry of loess (GONG et al. 1987, LAUTRIDOU et al. 1984, PETROV et al. 1984, SCHNETGER 1992, TAYLOR et al. 1983, WEN et al. 1985). The young loess of Hungary was studied by PÉCSI-DONÁTH (1985). Geochemical facies analysis of loess in the North-Eastern Great Hungarian Plain was performed by SZŐŐR et al. (1992a, 1992b).

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During the last years 15 sections were sampled for sedimentological, geochemical and paleontological examination using fine stratigraphic methods. Samples were collected by the 25 cm or by the layer. Situation of the sampled profiles is shown by *Fig. 1*.

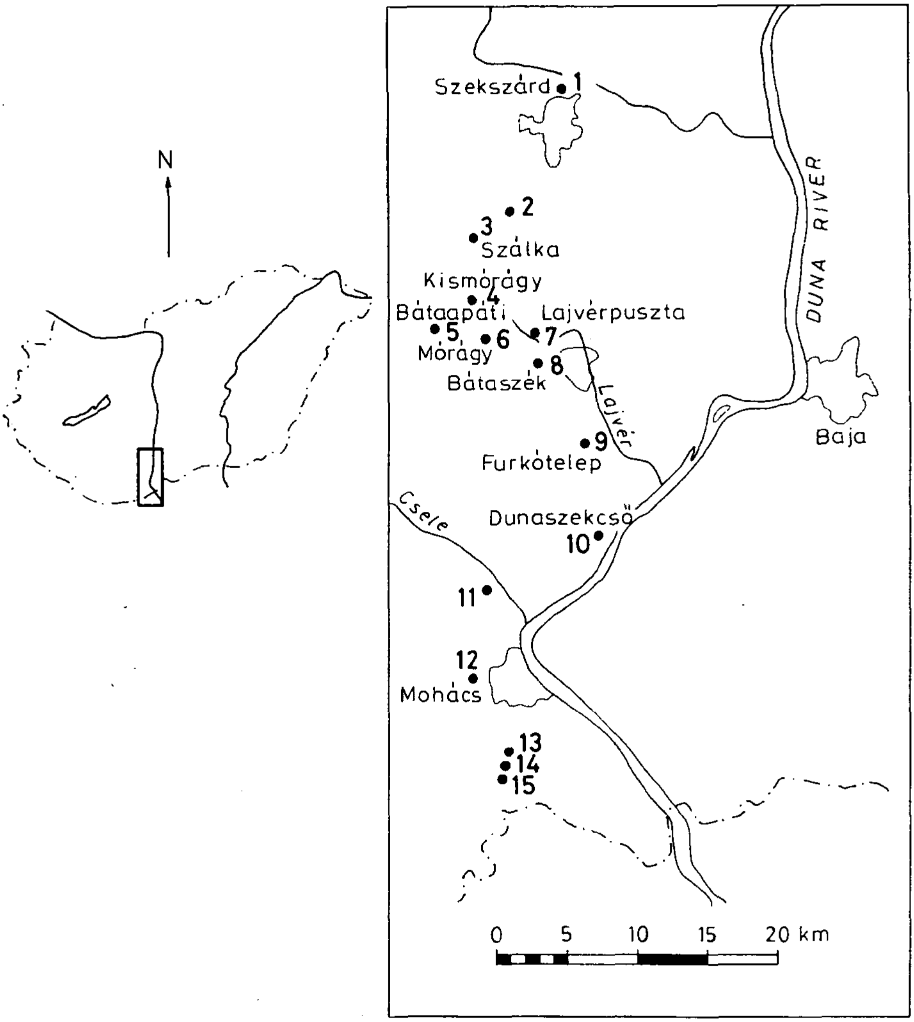

Fig. 1. Location map of the examined profiles

ANALYTICAL METHODS

After determination of grain-size distribution and carbonate content of the samples, mineral and element composition of 66 samples of loess and that of 23 samples of paleosol were examined in the grain-size fraction of less than 71 μm. X-ray measures were used for determination of the mineral composition; in cases of 25 samples, fraction of less than 5 μm was also examined, and these were prepared with ethylene-glycol for determination of clay minerals. The calcite-dolomite ratios were determined by the method of TENNANT-BERGER (1957). Determination of carbonate and clay minerals was promoted by termoanalytical examinations. Inorganic carbon was removed with HCl, and then organic carbon content was determined by using LECO Carbon-Sulfur Determinator. For the determination of trace and major elements, destructive attack was performed by using HF-$HClO_4$-HNO_3 mixture in Teflon bomb under high pressure. Al, Fe (total), Mn, Mg, Ca, Na, K, Li, Zn and Sr were analyzed by flame AAS (Na, K and Li with emission), and Cr, Pb and Cu were analyzed by graphite-tube AAS (Perkin Elmer 4100). After HF-H_2SO_4 attack in autoclave, Fe^{2+} was measured by titration. Si was measured by RFA, while Ti and P were analyzed by spectrophotometry (using by the Tiron's and the molybdenum yellow methods). All methods are described in HEINRICHS-HERRMANN (1990).

GRAIN-SIZE DISTRIBUTION AND COLOR OF THE SEDIMENTS

Results of the examinations of the grain-size distribution can be summarized as it follows:

– Main grain-size fraction of the loesses ranges from 20 to 50 μm (43–57 weight %), ratios of the clay and the sand fraction range 11–18 and 4–14 weight %, respectively. The derasional loess has a similar grain-size distribution, but ratio of the clay fraction is a little higher (16–20 weight %).

– Because of weathering, grain-size distribution of the paleosols is characterized by quite higher ratio of the clay fraction (19–41 weight %) and lower ratio of the coarse aleurite (26–42 weight %). The chernozem-like steppe soil has the highest clay and the lowest coarse aleurite fractions.

– Grain-size distributions of the different sediments are listed in Table 1.

TABLE I

Grain-size distribution of loesses and paleosols (weight %)

	< 2 μm	2–5 μm	5–10 μm	10–20 μm	20–50 μm	50–100 μm	100–200 μm
Loess	11.2–17.4	3.2–8.1	7.2–13.1	12.5–21.7	43.1–57.4	4.1–14.6	0.2–1.1
Der. loess	16.1–20.4	4.3–5.2	7.4–13.9	11.4–15.2	45.6–49.1	6.2–8.3	0.4–1.5
Humic soil	19.5–20.3	6.4–9.1	5.4–8.2	15.3–18.1	40.3–42.5	7.5–9.3	0.9–2.4
Chern. st. soil.	22.7–43.6	2.9–8.4	10.7–14.5	10.7–14.5	24.6–38.9	5.8–9.7	0.2–2.8

Color of the sediments was determined by the ROCK-COLOR CHART in dry state. Loess samples are dusky yellow (5Y 6/4) and its darker and lighter shades, the humic loess horizon are dark yellowish brown (10Y 5/4) and color of the chernozem-like steppe soils ranges from moderate yellowish brown (10 YR 5/4) through dark yellowish brown (10 YR 4/2) to dusky yellowish brown (10 YR 2/2).

MINERAL COMPOSITION

The X-ray (*Fig. 2*) and the thermoanalytical (*Fig. 3*) measures show that loesses and paleosols dominantly consist of quartz (31,1–48,8%), feldspars (5,2–13,6%), carbonates (2,72–38,20%), micas (muscovite and biotite) and clay minerals of varying quantity (Table

2). By the X-ray diffraction examination of the fractions of less than 5 μm illite, montmorillonite (smectite), chlorite and the illite-montmorillonite mixed layers as dominánt components of the clay fraction could be detected in each of the samples, while kaolinite, vermiculite, hydrobiotite and the montmorillonite-chlorite as well as the chlorite swelling mixed layers were of secondary quantity. Clay fraction of the loesses is characterized by illite and montmorillonite content with a relatively low variation, while it is characteristic for the clay fraction of the paleosols that montmorillonite (smectite) and kaolinite contents are higher than that of loesses.

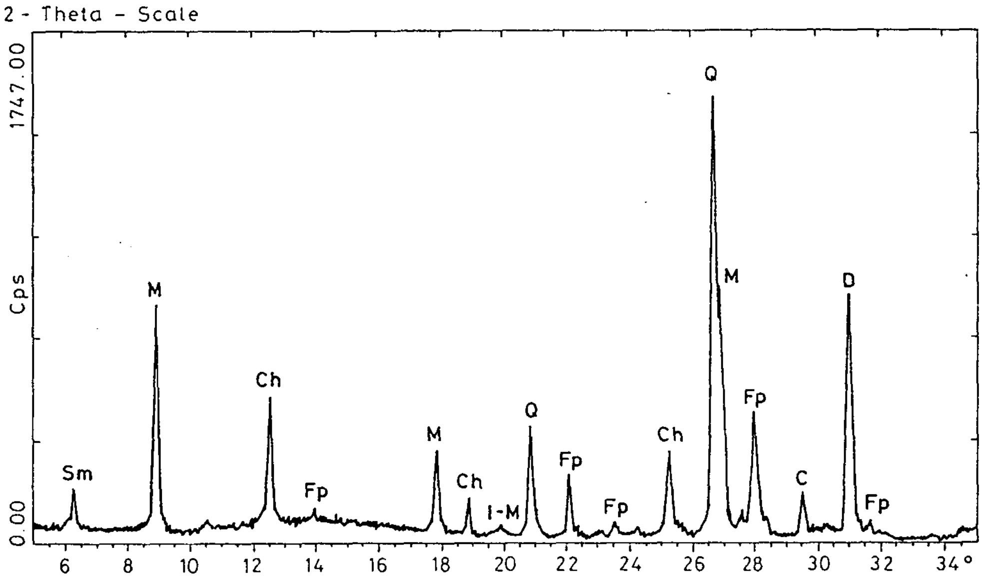

Fig. 2. X-ray curve characteristic for loess. Sample from the 0,50–0,75 m of the profile 14 (South of Mohács) Q = quartz, D = dolomite, C = calcite, Fp = feldspars, M = muscovite, Ch = chlorite, Sm = smectite, I-M = illite-montmorillonite mixed layers

Carbonate content (calcite and dolomite) of the studied loess samples is extremely high (10,7–38,2 weight %, the mean value is 24,36 weight %, the standard deviation is 6,06). According to several authors (SZILÁRD 1983, PÉCSI 1993) samples having carbonate content higher than 22 weight % can rather be considered as loessy formation (carbonate accumulating horizons), however, other authors (FÜCHTBAUER 1988, HÄDRICH 1975) consider sediments of high (as high as 30 and even 40 weight %) carbonate content as loess.

The dolomitic ratio is strikingly high within the carbonate content. According to FÜCHTBAUER (1988) dominant part of the carbonate content is calcite, and dolomite occurs only in special cases. According to international analyses (HÄDRICH 1975, PYE 1983, TAYLOR et al. 1983, SCHNETGER 1992), the calcite-dolomite ratio of the carbonate contents in samples from different places of the world ranges from 2:1 to 3:1. Ratio of the dolomite in the carbonate fraction of the 66 studied loess samples ranges from 49 to 88%, its average is 69,4% (standard deviation: 10,6), therefore the average calcite-dolomite ratio is 1:2. High dolomite content was detected for young loess of Hungary by PÉCSI-DONÁTH

(1985) and GEREI et al. (1985), as well. It can be supposed that this high dolomite content is primary, i. e., it accumulated as dust contemporaneously together with other mineral components of the loess. Average carbonate content of the derasional loess is 19,4 weight % (standard deviation is 5,54).

Paleosols have much lower carbonate content due to its leaching: humic loess horizon: 12,73 weight % (standard deviation: 4,39), chernozem-like steppe soil: 2,95 weight % (standard deviation: 0,89), but calcite has higher ratio (57–82%) than dolomite for these samples. Therefore, calcite-dolomite ratio of the paleosols ranges from 2:1 to 3:1. The higher calcite ratio of the paleosols can explained by the fact that quantity of the calcite increases because of the more solvable dolomite, which has low ordered crystal structure, leaches more rapidly. Mobility of Ca and Mg ion is influenced by pH relations, as well.

TABLE 2

Quartz. feldspar and carbonate contents of loesses and paleosols (%)

	Quartz	Feldspar	Calcite	Dolomite
Loess	31.1–48.8	9.6–13.6	3.1–16.2	7.7–30.0
Der. loess	33.7–40.7	5.2–12.7	1.8–4.5	7.1–14.9
Humic loess hor.	35.3–35.8	3.9–7.6	1.1–5.9	5.3–6.9
Chern. steppe soil	32.2–52.8	4.7–8.8	0.8–5.5	0.4–1.3

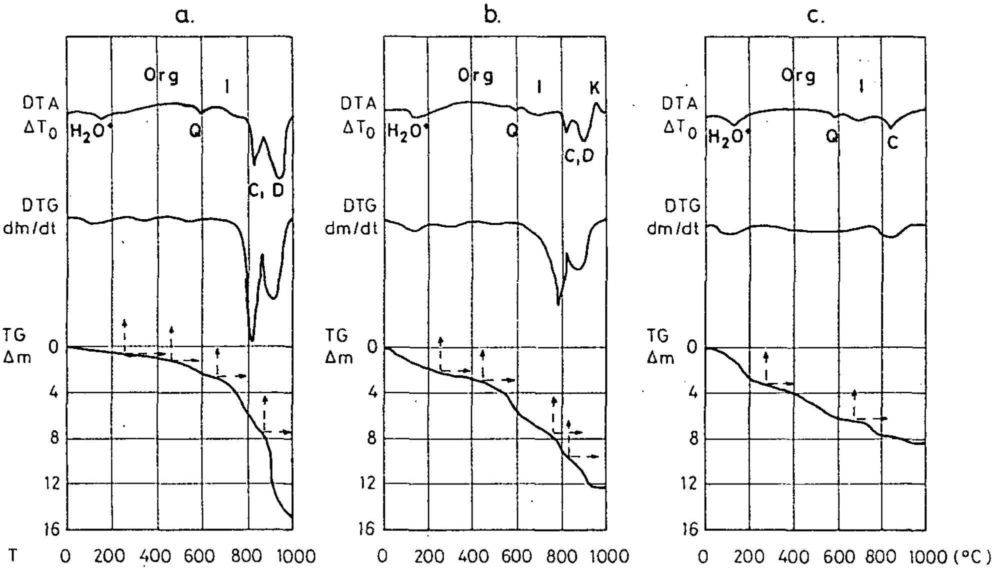

Fig. 3. Thermoanalytical analyses of different sediment types.
a: typical loess from 1,50–1,75 m of the profile 9 near Furkótelep. b: humic loess horizon from 9,00–9,25 m of the profile 10 of Dunaszekcső, c: chernozem-like steppe soil from 5,10–5,35 m of profile 1 north of Szekszárd. H_2O^+ = weakly bound water, Org = organic material, Q = quartz, I = illite, C = calcite, D = dolomite, K = kaolinite

ELEMENT COMPOSITION

Major chemical components of the studied loesses are SiO_2 (49,10–64,53%), Al_2O_3 (8,04–11,82%), CaO (7,30–14,27%), MgO (3,49–5,16%), Fe_2O_3 (2,30–3,46%), Na_2O (0,89–1,35%), K_2O (1,39–1,95%) as well as, in small quantity, TiO_2 (0,50–0,88%), P_2O_5 (0,12–0,19%) and MnO (0,058–0,088%). The organic carbont content ranged from 0,06 to 0,12%. Chemical components of the derasional loesses have same intervals. Average of the iron oxidation indexes of the loesses ($OFe=2Fe_2O_3/FeO$) is 11,03 (standard deviation is 4,64). Quantities of the trace elements are the following: Sr: 222–513 ppm, Li: 20–34 ppm, Cr: 52–86 ppm, Cu: 19–38 ppm, Zn: 44–65 ppm, Pb: 4–14 ppm. These values are correspond to the trace element composition of loess from the different localities of the world (GONG et al. 1984, LAUTRIDOU et al. 1984, PETROV et al. 1984, SCHNETGER 1992, WEN et al. 1985) and that of the Hungarian loesses which have been studied (PÉCSI-DONÁTH 1985).

In the paleosols, contents of SiO_2 (55,69–69,38%), Al_2O_3 (8,52–13,36%), TiO_2 (0,69–0,85%), Fe_2O_3 (2,33–4,12%), MnO (0,066–0,101%), Na_2O (1,01–1,65%), K_2O (1,54–2,20%), P_2O_5 (0,13–0,22%), C_{org} (0,11–0,37%) are high, while those of MgO (1,45–3,78%) and CaO (0,94–11,94%) are quite low as compared to major element contents of the loesses. Increase of the Na_2O content of the paleosols is small, and in some types (fossil soils of old loesses) its decrease can be also observed. Among trace elements of the paleosols, contents of Li (25–40 ppm), Cr (62–94 ppm), Zn (54–82 ppm) and Pb (6–26 ppm) are higher, while those of Sr (167–348 ppm) and Cu (22–27 ppm) are lower (Table 3). Iron oxidation index (O_{Fe}) of the paleosols is 20,10 (standard deviation is 12,13) as an average.

H_2O-content is ranged froml,25 to 3,26% for the loesses, from 2,45 to 3,06% for derasional loesses, from 3,66 to 4,53% from humic loess horizons, and from 4,12 to 6,50 for chernozem-like steppe soils. Distribution of the H_2O content of the different sediments shows a positive correlation with the quantity of the clay minerals.

Geochemical composition of some representative loess and paleosol samples is listed in Table 4.

During the weathering, due to their physical and chemical resistance, SiO_2 and TiO_2 accumulate in the paleosols, and accumulation of Al_2O_3, Fe_2O_3 and alkalines can also be observed. K is adsorbed on the surface of the clay minerals, and Li mainly occurs micas accumulated in soils. Quantity of the alkaline earth metals (Mg, Ca, Sr) strongly decreases in the paleosols because their carbonate minerals are dissolvable and, in this way, washed out from them. As the pedogenesis becomes more and more intensive, solution of the carbonates and accumulation of Al_2O_3 and Fe_2O_3 intensify.

On the basis of the geochemical data FeO/Fe_2O_3, CaO/MgO, $(CaO+K_2O+Na_2O)/Al_2O_3$ and K_2O/Na_2O ratios were calculated (WEN et al. 1985). FeO/Fe_2O_3 and $(CaO+K_2O+Na_2O)/Al_2O_3$ ratios decrease because of the accumulation of Fe_2O_3 and Al_2O_3 during the weathering. Mg can also link to the clay minerals accumulated during the weathering process, and, therefore, quantity of MgO decreases in a small degree. Beside CaO/MgO ratio is higher for the paleosols. Value of the K_2O/Na_2O is increased by weathering, and it reaches its maximum in the paleosols. Potassium is an important constituent of the clay minerals (illite) and can be adsorbed on the surface of the clay minerals, therefore, weathered sediments and paleosols are more rich in potassium.

On the basis of the geochemical data, the studied loesses can be divided into two groups: weakly weathered loesses and weathered loesses. The weathered loess samples are characterized by higher TiO_2, Al_2O_3, Fe_2O_3, K_2O, Li, Cr, Zn and lower CaO, Sr contents.

TABLE 3

Geochemical data of different sediment types

	Weakly weathered loess (24 samples)			Weathered loess (18 samples)		
	Limit	Average	S.D.	Limit	Average	S.D.
SiO_2 %	49.41–64.53	**57.27**	5.47	49.10–62.79	**55.80**	3.96
TiO_2 %	0.50–0.78	**0.67**	0.06	0.58–0.88	**0.73**	0.09
Al_2O_3 %	8.04–9.87	**8.81**	0.45	8.54–11.82	**10.45**	0.96
Fe_2O_3 %	2.30–3.09	**2.64**	0.19	2.64–3.46	**3.17**	0.27
FeO %	0.18–0.71	**0.49**	0.13	0.39–0.64	**0.51**	0.09
MnO %	0.062–0.086	**0.070**	0.005	0.058–0.088	**0.075**	0.009
MgO %	3.88–5.16	**4.47**	0.26	3.49–4.56	**4.01**	0.35
CaO %	9.80–17.17	**11.97**	1.81	7.30–14.27	**9.48**	2.24
Na_2O %	0.89–1.34	**1.21**	0.11	0.96–1.35	**1.27**	0.10
K_2O %	1.39–1.68	**1.52**	0.08	1.48–1.95	**1.78**	0.14
P_2O_5 %	0.12–0.18	**0.15**	0.02	0.14–0.19	**0.16**	0.01
Corg %	0.06–0.14	**0.09**	0.02	0.06–0.12	**0.09**	0.01
Li ppm	20–28	**24**	2	23–34	**29**	4
Cr ppm	52–78	**64**	6	59–86	**73**	8
Cu ppm	22–38	**28**	4	19–33	**27**	4
Zn ppm	44–54	**50**	3	53–65	**58**	4
Sr ppm	306–513	**400**	49	222–414	**324**	56
Pb ppm	4–14	**8**	2	4–9	**7**	1
	Humic loess horizon (4 samples)			**Chernozem-like steppe soil (8 samples)**		
	Limit	Average	S.D.	Limit	Average	S.D.
SiO_2 %	55.69–59.73	**57.94**	2.04	62.13–69.38	**64.75**	2.83
TiO_2 %	0.69–0.85	**0.80**	0.07	0.78–1.03	**0.93**	0.08
Al_2O_3 %	8.52–12.51	**11.19**	1.85	11.61–13.36	**12.50**	0.67
Fe_2O_3 %	2.33–3.42	**3.03**	0.49	3.64–4.12	**3.83**	0.19
FeO %	0.78–0.97	**0.88**	0.09	0.31–0.75	**0.51**	0.14
MnO %	0.071–0.086	**0.079**	0.06	0.066–0.101	**0.086**	0.013
MgO %	2.72–3.78	**3.34**	0.51	1.45–2.12	**1.90**	0.36
CaO %	6.21–11.94	**8.84**	2.54	0.94–6.37	**3.18**	1.98
Na_2O %	1.13–1.65	**1.42**	0.22	1.01–1.46	**1.29**	0.16
K_2O %	1.54–2.06	**1.84**	0.23	1.84–2.20	**2.03**	0.12
P_2O_5 %	0.17–0.20	**0.19**	0.01	0.13–0.22	**0.17**	0.03
Corg %	0.16–0.37	**0.24**	0.09	0.11–0.32	**0.21**	0.09
Li ppm	23–35	**32**	5	32–40	**37**	3
Cr ppm	62–93	**84**	15	85–94	**90**	3
Cu ppm	25–26	**25**	1	22–27	**25**	3
Zn ppm	54–74	**65**	9	68–82	**74**	5
Sr ppm	281–348	**310**	28	167–288	**233**	11
Pb ppm	6–9	**8**	2	9–26	**11**	6

TABLE 4

Element composition of some representative samples

Weakly weathered loess: 1. Szálka. profile 3. 1.50–1.75; 2. Dunaszekcső, profile 10, 2.40–2.65 m; Weathered loess: 3. Bátaapáti, profile 5, 1.75–2.00 m; 4. Mohács, profile 11, 1.50–1.75 m; Humic loess horizon: 5. Dunaszekcső, profile 10, 7.25–7.50 m; 6. Dunaszekcső, profile 10, 9.25–9.50 m; Chernozem-like steppe soil: 7. Szekszárd, profile 1, 5.10–5.35 m; 8. Mohács, profile 12, 2.85–3.15 m

	1.	2.	3.	4.	5.	6.	7.	8.
SiO_2 %	51,17	52,20	55,20	55,17	56,74	55,69	63,62	63,62
TiO_2 %	0,67	0,69	0,75	0,65	0,82	0,85	0,85	0,92
Al_2O_3 %	8,59	8,87	10,30	9,89	12,33	11,41	11,97	13,36
Fe_2O_3 %	2,70	2,52	3,04	3,04	3,26	3,11	3,73	4,12
FeO %	0,44	0,61	0,51	0,44	0,97	0,83	0,50	0,59
MnO %	0,072	0,070	0,077	0,062	0,079	0,078	0,070	0,093
MgO %	4,56	4,64	4,09	4,22	3,78	2,72	2,16	2,12
CaO %	12,52	12,25	9,30	10,10	7,43	9,78	4,35	3,00
Na_2O %	1,13	1,25	1,35	1,29	1,65	1,38	1,38	1,41
K_2O %	1,49	1,53	1,88	1,68	2,06	1,78	1,99	2,20
P_2O_5 %	0,16	0,13	0,18	0,18	0,18	0,17	0,17	0,14
Corg %	0,10	0,09	0,10	0,09	0,16	0,24	0,32	0,17
Ign. l. %	15,72	15,13	13,19	13,23	10,44	12,08	8,96	8,31
Total %	99,68	99,98	99,96	100,04	99,91	100,12	100,07	99,75
Li ppm	21	26	24	30	34	32	36	39
Cr ppm	64	63	78	69	93	87	85	90
Cu ppm	29	27	25	23	25	25	23	26
Zn ppm	49	49	59	54	74	63	68	79
Sr ppm	447	462	369	322	299	311	252	288
Pb ppm	10	9	8	5	9	7	10	6

Lower FeO/Fe_2O_3, CaO/MgO, $(CaO+K_2O+Na_2O)/Al_2O_3$ and higher K_2O/Na_2O ratios are also characteristics for the weathered loesses (Table 5). Loess samples from exposures of Furkótelep, Dunaszekcső, Lajvérpuszta and from upper parts of the profiles of Szálka and north of Szekszárd belong to the weakly weathered loesses. Exposures near Bátaapáti and Mohács, loesses from the exposure south of Szekszárd, samples from lower parts of the profile north of Szekszárd can be considered as weathered loess. The studied derasional loesses (from the exposure lying northern-west of Mohács) can also be ordered into this group.

Geochemical data of the paleosols of different genesis show important differences. Related to the loesses, humic loess horizons (profiles of Dunaszekcső, Mohács and Lajvérpuszta) have higher TiO_2, Al_2O_3, K_2O, Na_2O, P_2O_5, Cr and Zn contents; and quantities of CaO, MgO and Sr do not show considerable decrease because carbonates are not leached from these levels. Among the four studied sediment types (weakly weathered loess, weathered loess, humic loess horizons, chernozem-like steppe soils), humic loess horizons contain the highest C_{org} contents. Chernozem-like steppe soils have the highest SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, K_2O, Li, Cr, Zn, Pb, and the lowest CaO, MgO and Sr contents (Table 4). As the intensity of the weathering increases, CaO/MgO and $(CaO+K_2O+Na_2O)/Al_2O_3$ ratios for the paleosols become lower and lower, and their values are lowest for the chernozem-like steppe soils. The highest K_2O ratio is characteristic for the chernozem-like steppe soils (Table 5).

TABLE 5

Geochemical ratios of different sediment types

	Weakly weathered loess (24 samples)			Weathered loess (18 samples)		
	Limit	AVG	S.D.	Limit	AVG	S.D.
FeO/Fe_2O_3	0,06–0,27	**0,18**	0,06	0,08–0,22	**0,15**	0,04
CaO/MgO	2,23–4,42	**2,77**	0,54	1,49–3,19	**2,21**	0,40
$CaO+K_2O+Na_2O/Al_2O_3$	1,36–2,42	**1,67**	0,24	0,88–1,61	**1,09**	0,23
K_2O/Na_2O	1,07–1,74	**1,31**	0,16	1,18–1,66	**1,42**	0,10
	Humic loess horizon (4 samples)			Chernozem-like steppe soil (8 samples)		
	Limit	AVG	S.D.	Limit	AVG	S.D.
FeO/Fe_2O_3	0,21–0,30	**0,26**	0,04	0,10–0,20	**0,13**	0,04
CaO/MgO	1,02–3,59	**2,14**	1,07	0,60–3,54	**1,61**	0,52
$CaO+K_2O+Na_2O/Al_2O_3$	0,40–1,13	**0,80**	0,31	0,32–0,80	**0,52**	0,18
K_2O/Na_2O	1,25–1,53	**1,34**	0,13	1,26–1,88	**1,59**	0,19

According to the matrix of the correlation coefficient of weathered loesses, elements, which have different geochemical characters and react to weathering in different way, can unambiguously be distinguished (*Fig. 4*). One group is formed by elements accumulating during weathering (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, Na_2O, K_2O, Li, Zn, Cr, P_2O_5); these show significant correlation. Elements leaching during weathering (MgO, CaO, Sr) belong to the other group, and these are in significant correlation with each other, too. However, there is only negative correlation between the elements of these two groups (*Fig. 4*).

CONCLUSIONS

Mineral composition of the loesses of this area is characterized by high carbonate content with a dominance of dolomite; the calcite-dolomite ratio is 1:2. This high dolomite content is of primary origin, and, therefore, it was simultaneously deposited together with the other mineral constituens. Carbonate content of the paleosols is lower due to weathering, however, the calcite-dolomite ratio is shifted between 2:1 and 3:1.

Element composition of loesses depends on paleoclimatic and geochemical circumstances as well as on geochemical properties of the elements, and this makes a geochemical classification of loesses possible. Loesses of the studied area can be divided into two groups: weathered loesses and weakly weathered loesses. Comparing with the weakly weathered loesses, the weathered loesses are characterized by higher TiO_2, Al_2O_3, Fe_2O_3, K_2O, Li, Cr, Zn and lower CaO, Sr contents. In the case of the weathered loesses the FeO/Fe_2O_3, CaO/MgO, $(CaO+K_2O+Na_2O)/Al_2O_3$ ratios are lower, while the K_2O/Na_2O ratio is higher.

The geochemical data reflect the intensity of weathering and that of pedogenesis for the paleosols. Therefore, the genetically different paleosols can be distinguished. Humic loess horizon represent an intermediate formation between the loesses and the chernozem-like steppe soils on the basis of their carbonate contents and element composition, as well. Among the sediments studied, the pedogenetic and weathering intensity reaches the maximum in the cases of the chernozem-like steppe soils. This soil type has the highest SiO_2,

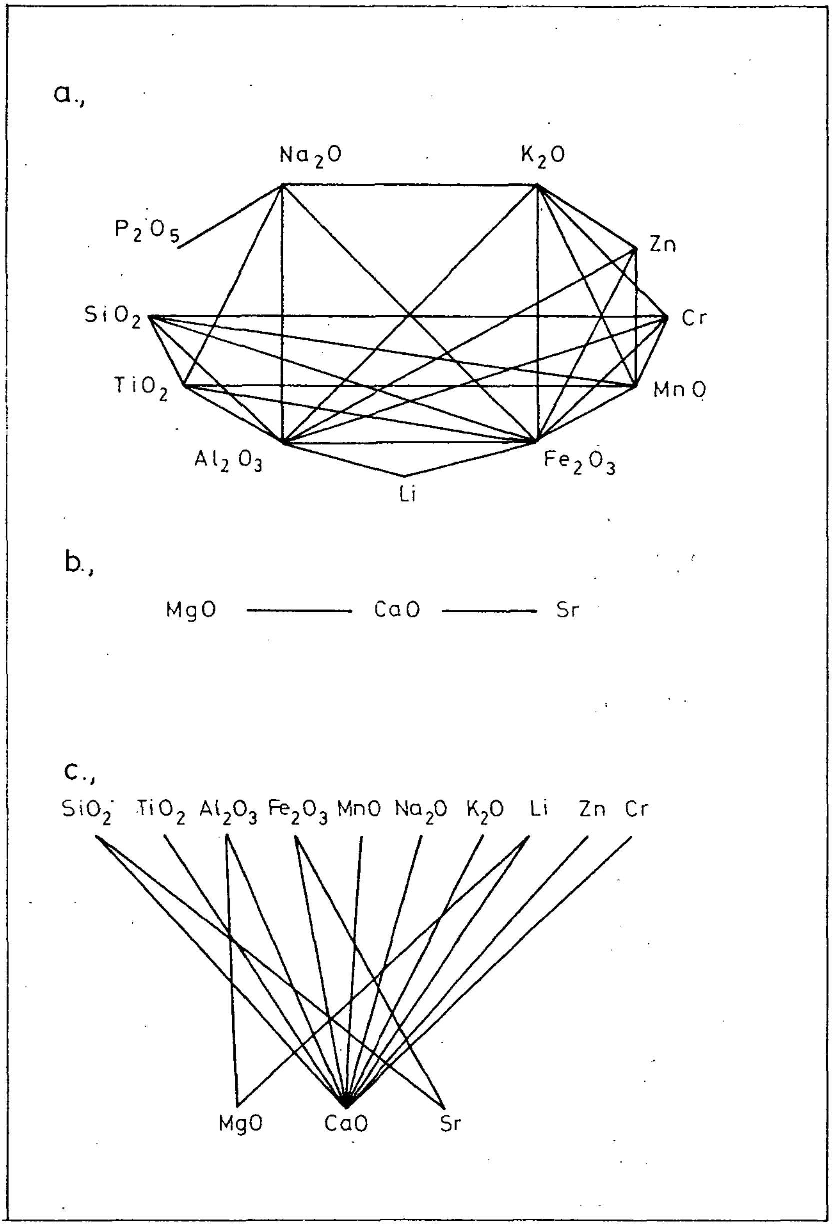

Fig. 4. Correlative profiles of geochemical data of the weathered loesses on the basis of correlation matrix of geochemical data of 18 samples. Coefficiens > 0.5 and significance level > 99.9
a: positive correlative connections of the components accumulating during the weathering
b: positive correlative connections of the components decreasing during the weathering
c: negative correlative connections between the elements accumulating and the elements decreasing during the weathering

TiO_2, Al_2O_3, Fe_2O_3, MnO, K_2O, Li, Cr, Zn, Pb values and the lowest CaO, MgO and Sr contents.

Comparison of the geochemical composition and the stratigraphic position (i. e., stratigraphic correlation on a geochemical base) needs further studies. In this respect, valuable results can mainly be expected from studies of paleosols.

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